National Aeronautics and Space Administration

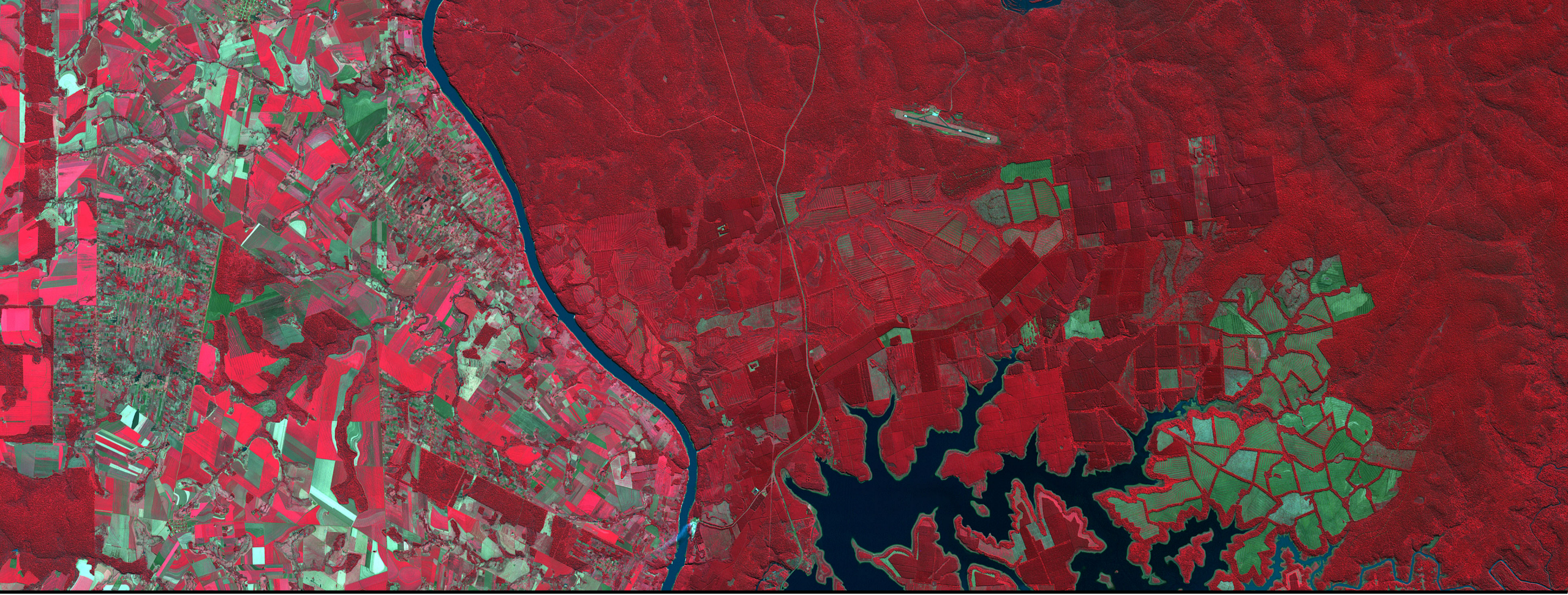# SMAP Data Access and Analysis

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2 December 2017

Objectives

By the end of this exercise, you will be able to:

- Access SMAP data

- Visualize and analyze SMAP data

Outline

- SMAP Data Products
  - SMAP Data Product Summary
  - Product Configuration
- Discover, Download, and Visualize SMAP Data
  - Sites
  - Tools
- Download SMAP Data
- SMAP Data Analysis
  - Extracting SMAP Soil Moisture Values
  - Open the File

SMAP Data Products

SMAP Data Products

Data Product Short Name	Description	Grid Resolution	Granule Extent
L1A_Radar*	Parsed Radar Instrument Telemetry		Half Orbit
L1A_Radiometer	Parsed Radiometer Instrument Telemetry		Half Orbit
L1B_S0_LoRes*	Low resolution Radar σ_0 in Time Order	5x30 km (10 slices)	Half Orbit
L1C_S0_HiRes*	High Resolution Radar σ_0 on Swath Grid	1 km	Half Orbit
L1B_TB	Radiometer T_B in Time Order	39 x 47 km	Half Orbit
L1C_TB	Radiometer T_B	36 km	Half Orbit
L2_SM_A*	Radar Soil Moisture (includes Freeze-Thaw)	3 km	Half Orbit
L2_SM_P	Radiometer Soil Moisture	36 km	Half Orbit
L2_SM_AP*	Active-Passive Soil Moisture	9 km	Half Orbit
L3_FT_A*	Daily Global Composite Freeze/Thaw State	3 km	North of 45° N
L3_SM_A*	Daily Global Composite Radar Soil Moisture	3 km	Global
L3_SM_P	Daily Global Composite Radiometer Soil Moisture	36 km	Global
L3_SM_AP*	Daily Global Composite Active-Passive Soil Moisture	9 km	Global
L4_SM	Surface & Root Zone Soil Moisture	9 km	Global
L4_C	Carbon Net Ecosystem Exchange	9 km	North of 45° N

*Only available during the 2.5 months of radar operation (mid-April – July 7, 2015)

SMAP Data Product Summary

Updated SMAP Data Products

Data Product	Description	Grid Resolution	Algorithm Source
L1A_Radiometer	Radiometer Data in Time-Order	-	Mission DA
L1B_TB	Radiometer T_B in Time Order	39 x 47 km	Mission DA
L1C_TB	Radiometer T_B in Half-Orbits	36 km	Mission DA
L1C_TB_E	Radiometer T_B in Half-Orbits, Enhanced	9 km	Mission DA
L2_SM_P	Soil Moisture (Radiometer)	36 km	Mission DA
L2_SM_P_E	Soil Moisture (Radiometer)	9 km	Mission DA
L2_SM_SP	Soil Moisture (Sentinel Radar + Radiometer)	3 km	Mission DA
L3_FT_P	Soil Moisture (Radiometer)	36 km	Mission DA
L3_SM_P_E	Soil Moisture (Radiometer, Enhanced)	3 km	Mission DA
L3_SM_P	Soil Moisture (Radiometer)	36 km	Mission DA
L3_SM_P_E	Soil Moisture (Radiometer, Enhanced)	9 km	Mission DA
L4_SM	Soil Moisture (Surface & Root Zone)	9 km	Mission DA
L4_C	Carbon Net Ecosystem Exchange (NEE)	9 km	Mission DA

SMAP Product Configuration

- **All products are in HDF5 format**
  - Each SMAP HDF5 file contains the primary data parameters (e.g., soil moisture, freeze/thaw, sensor data) and all data used in the production of those parameters
  - Files also include metadata, geolocation information, quality flags, etc.
- **Projection: EASE-Grid 2.0**
  - Equal-area projection
  - Level 2, 3, 4, and radiometer L1C are in this projection

- **Values**
  - Radiometer data (brightness temperature) is in Kelvin
  - Radar data is in sigma naught
  - Soil moisture is a volumetric measurement expressed as cm3/cm3
  - Freeze/thaw is a binary measurement, either frozen or thawed
  - Net ecosystem exchange is in grams of carbon/square meter per day

Discover, Download,
and Visualize SMAP Data

Sites to Discover, Download, and Visualize SMAP Data

NSIDC: Data Search, Documentation, & Access

http://nsidc.org/data/search/

Worldview: Data Visualization and Download

http://worldview.earthdata.nasa.gov/

Earthdata: Data Access & Output Customization

http://search.earthdata.nasa.gov/

National Snow & Ice Data Center (NSIDC)

http://nsidc.org/data/smap/
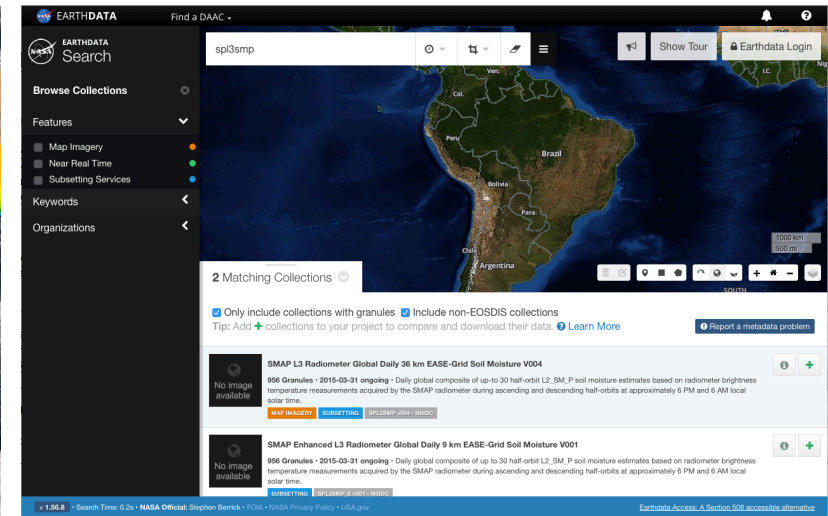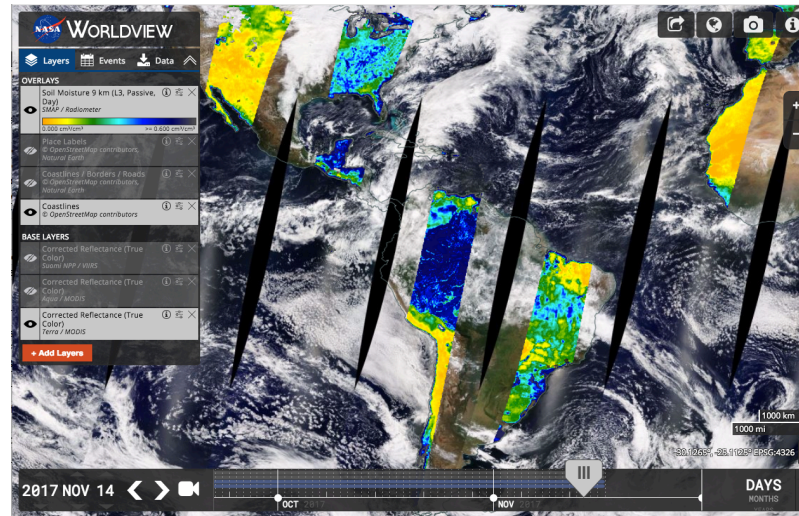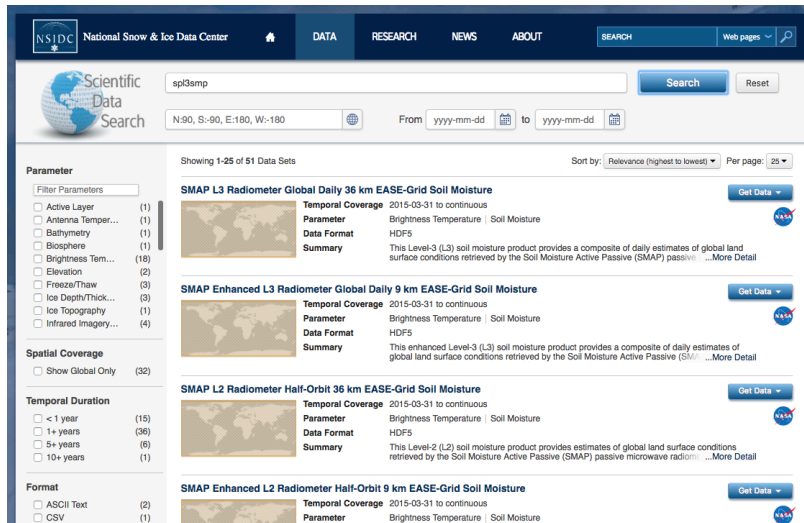
- Provides access to L1 radiometer data and all L2, L3, and L4 radiometer products

- Provides data access, dataset user guide documents, tools, news, published research, quality information, FAQs, and many other resources

- Direct access to SMAP data (with logins) through:
    - HTTPS: https://n5eil01u.ecs.nsidc.org/SMAP/

- Subscribe here: http://nsidc.org/daac/subscriptions.html for an automatic delivery of data as it becomes available

Worldview

http://worldview.earthdata.nasa.gov

- Data visualization and download
- Imagery is generally available within several hours
- Image output in JPEG, PNG, GeoTIFF, and KML

Earthdata Search

http://search.earthdata.nasa.gov/

- Allows you to search, order, and visualize all SMAP data
- You can perform a keyword, spatial, or temporal search
- Reformats, reprojects, and subsets services for most products

Tools

The HDF5 Group Support: http://support.hdfgroup.org/products/hdf5_tools/

Allows you to access and visualize SMAP HDF5 data using Python, NCL, MATLAB®, and IDL®
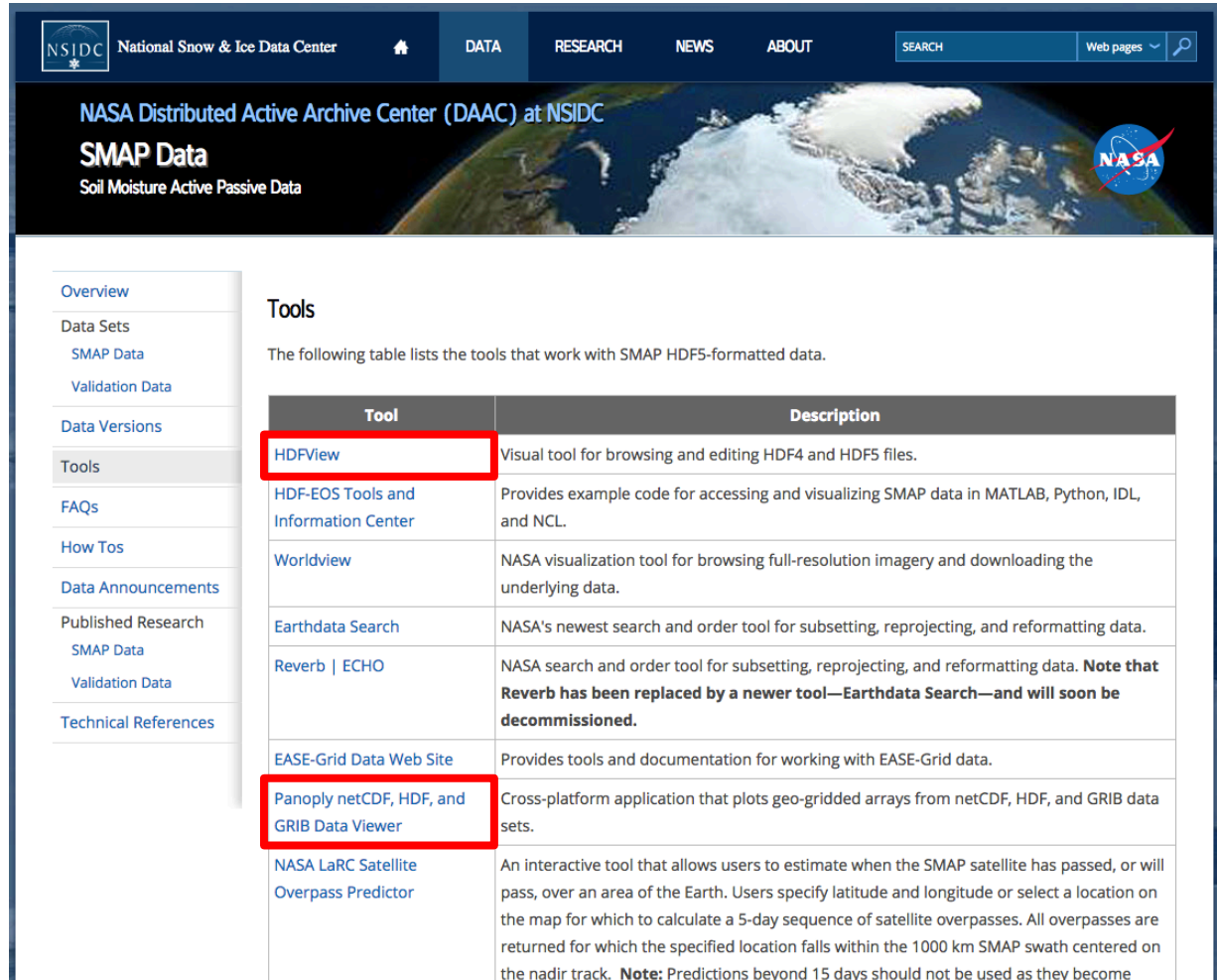
- Access HDF5 tools:
  - http://support.hdfgroup.org/products/hdf5_tools/index.html
- Download code in Python, NCL, MATLAB®, and IDL®:
  - http://hdfeos.org/zoo/index_openNSIDC_Examples.php#SMAP

Tools That Work with SMAP HDF5-Formatted Data

http://nsidc.org/data/smap/tools

- The native format of SMAP Data files is HDF5. NSIDC offers a tools page with a couple of tools for easy viewing of the HDF5 files: Panoply and HDFView
  - http://support.hdfgroup.org/products/hdf5_tools/index.html
- download code in Python, NCL, MATLAB®, and IDL®:
  - http://hdfeos.org/zoo/index_openNSIDC_Examples.php#SMAP

Tools That Work with SMAP HDF5-Formatted Data

http://nsidc.org/data/smap/tools

- For the SPL3SMP collection, Earthdata Search service options allow for the reformatting of the native HDF5 files to:

  – GeoTIFF, ASCII, NetCDF-3, NetCDF4-CF, KML, and HDF-EOS5

- For a detailed table of what subsetting, reformatting, and reprojection services are available for SMAP collections, please see:

  – https://support.nsidc.org/entries/97456598-What-data-subsetting-reformatting-and-reprojection-services-are-available-for-SMAP-data-

Download SMAP Data

Discovering SMAP Data at NSIDC

http://nsidc.org/

- NASA National Snow & Ice Data Center (NSIDC) is a Distributed Active Archive Center (DAAC)

- 1 of 12 NASA Earth Observing System Data and Information System (EOSDIS) DAACs

- Distributes nearly 500 NASA data sets
  - primarily focused on the cryosphere

Discovering SMAP Data at NSIDC

http://nsidc.org
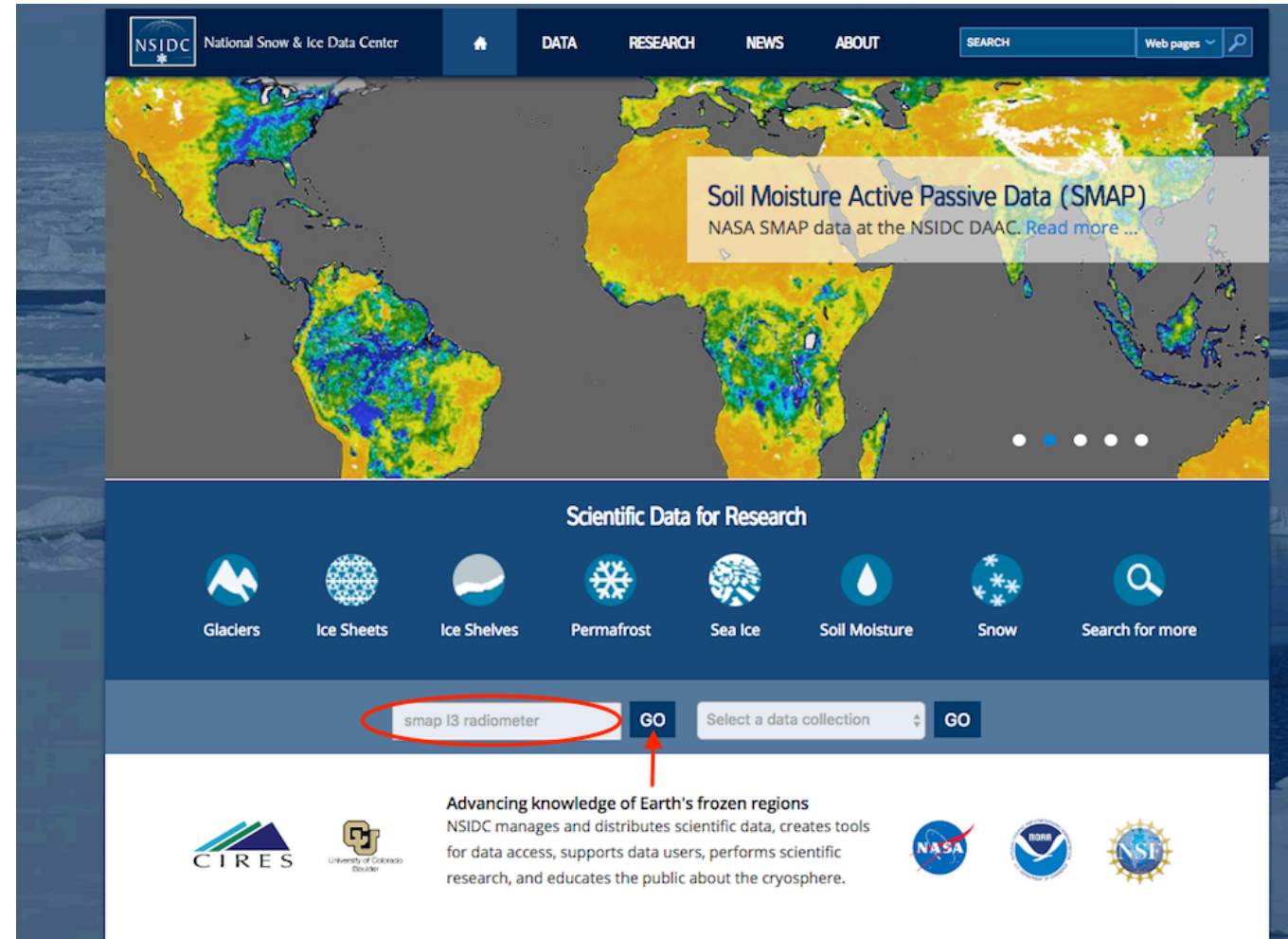
Clicking on the data set name in the Search results will take you to the collection's catalog page

Discovering SMAP Data at NSIDC

http://nsidc.org/

From the catalog page, you can use the **Get Data** options to explore options to download, visualize, and customize your data order

You'll also notice there's an overview of the data in the collection. Clicking on the different tabs will highlight how to cite this data, provide you with a user guide, and how to reach NSIDC for support

Discovering SMAP Data at NSIDC

http://nsidc.org/

Discovering SMAP Data at NSIDC

http://nsidc.org

Discovering SMAP Data at NSIDC

http://nsidc.org

Revisiting the Visualize button under Get Data, let's click Worldview and explore what this application has to offer

Exploring SMAP Data in NASA's Worldview

http://worldview.earthdata.nasa.gov/

- Worldview provides you with the ability to interactively browse global, full-resolution satellite imagery and download the underlying data & image files

- Uses Global Imagery Browse Services (GIBS)

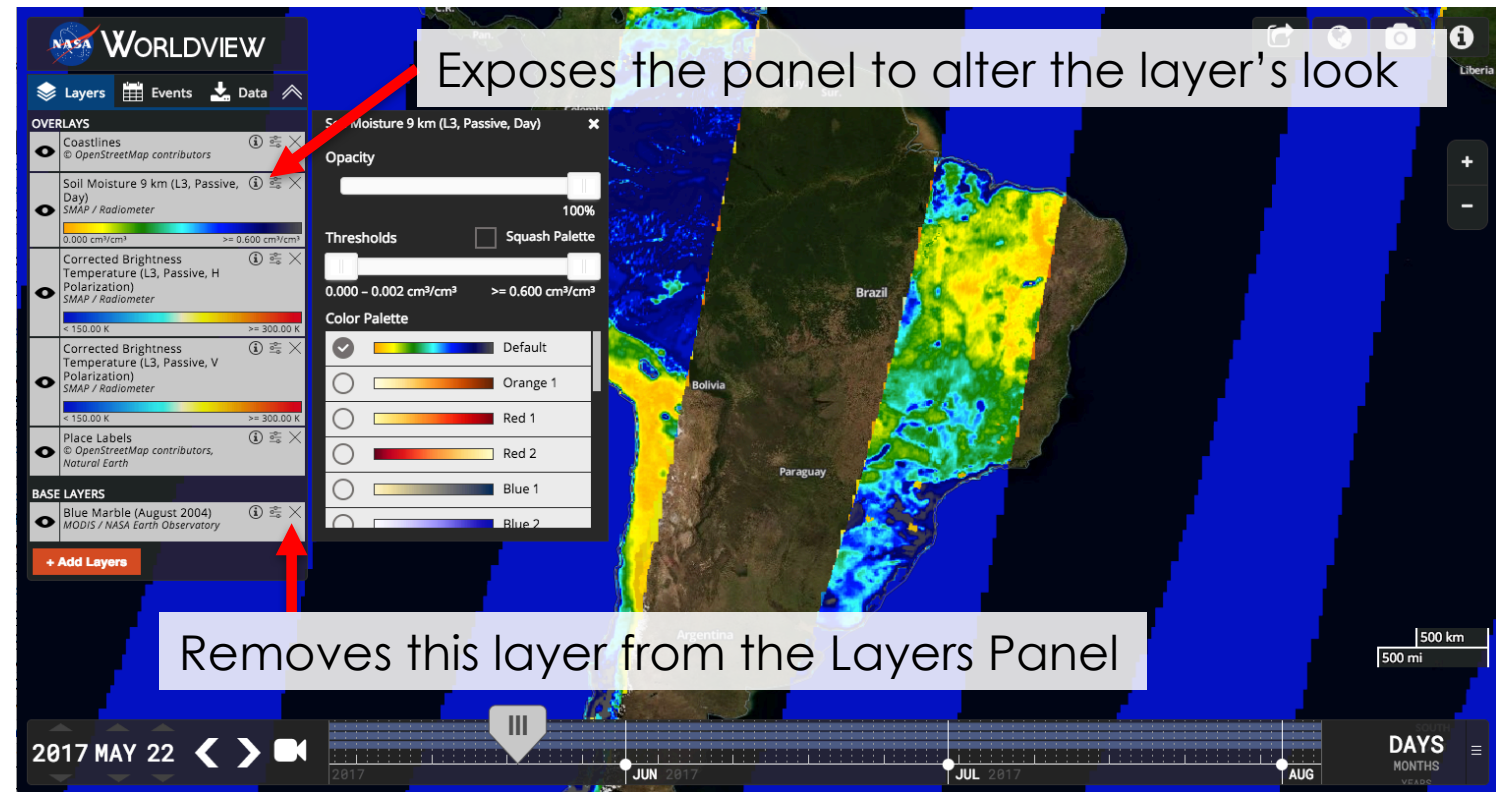- Most of the 100+ available products are updated within 3 hrs of observation
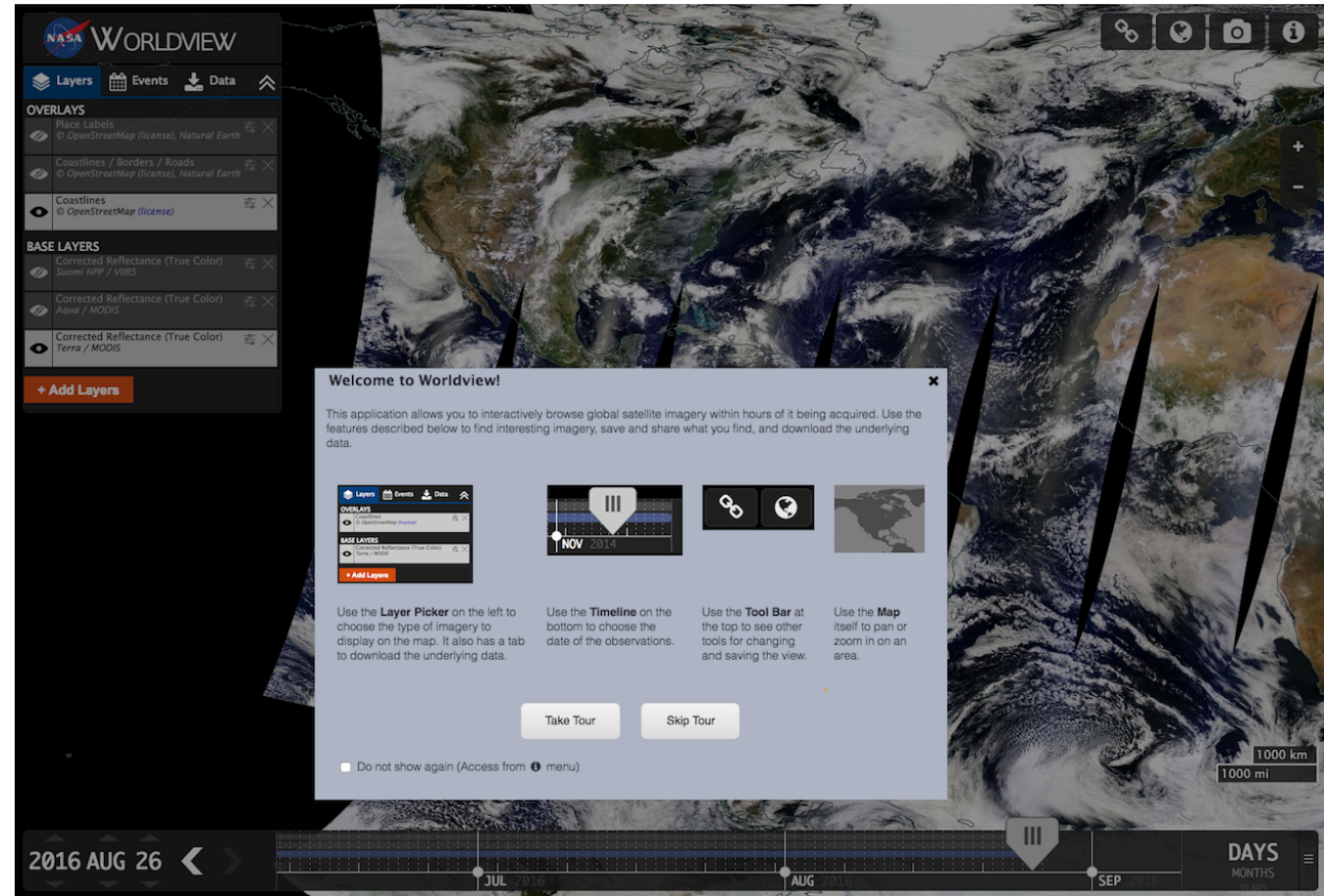
Visualizing and accessing SMAP Data from Worldview

Here, I've repositioned the Coastlines layer above Soil Moisture – notice the outlines visible in the Arctic over the Soil Moisture data

Also, clicking on the slider-bar symbol will open a dialogue to allow for changing the layer's opacity, thresholds and color palette

Clicking the "X" symbol for a layer removes it from the Layers panel

Exploring the Worldview Interface Further

Tabs for displaying current layers, current world events, or downloading underlying data

Collapse the layer pane

Turn overlay on or off

Click to browse through other layers to add

Exploring the Worldview Interface Further

Copy a URL of this map to share

Change the projection of the display

Take a snapshot of the interface

Information about Worldview

Zoom in or out – can also use your mouse's scroll wheel, double click on the map, or shift-drag to zoom to an area
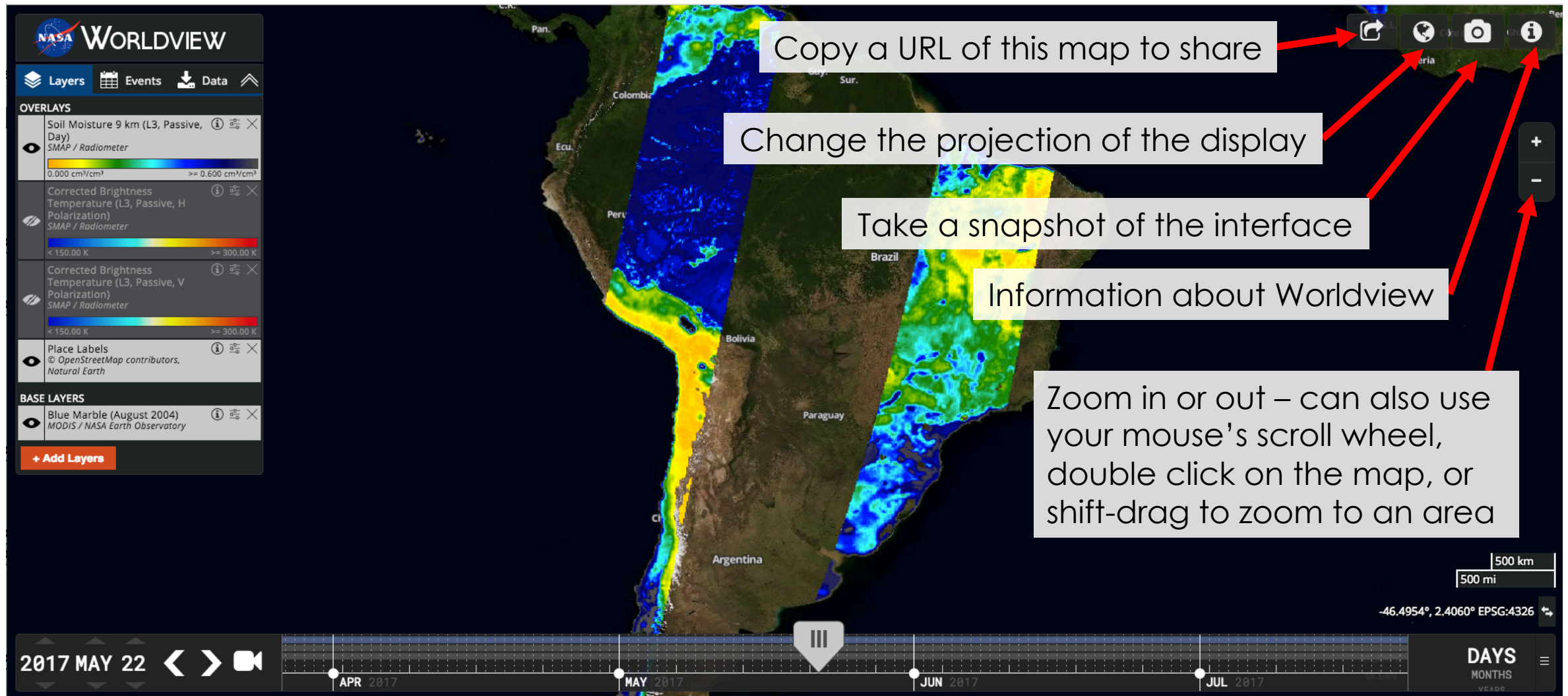
Exploring the Worldview Interface Further

Change the month, day, and year of the data displayed

Advanced forward or back a day at a time

The blue line indicates the layer is on and available during this time range

Gray lines indicate layers are off, but available during this time range

Slider control to change the date of the layer displayed

Collapse the timeline

Change the timeline's finest increment shown

Exploring Layer Options

Clicking the add layers button opens this dialogue where you can search by topic on the "Hazards and Disasters" tab or under the "Science Disciplines" tab where we are now. SMAP can be found under the Terrestrial Hydrosphere category.

You may also search by keyword at the top of this dialogue by click on the "Search" text

Click and type here for a keyword search

Click this category to expand and reveal SMAP data

SMAP Layer options:

Adding an Overlay: Coastlines / Borders / Roads

I've clicked on the "Other" category from the "Science Disciplines" tab and changed the default "Coastlines" layer to be "Coastlines/Borders/Roads" to add more detail to the map

Accessing SMAP Data with NASA's Earthdata Search

http://search.earthdata.nasa.gov/search
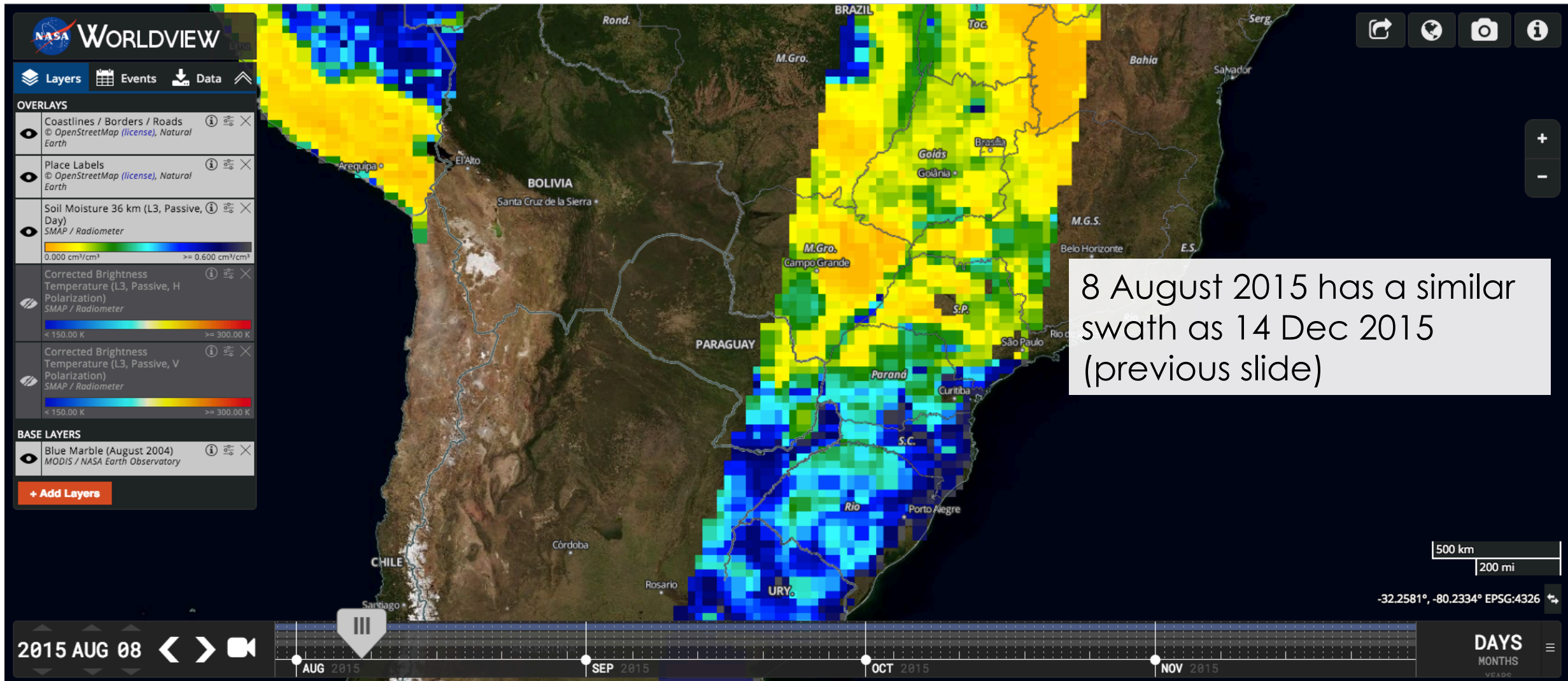
- Connects users to their data by making data search, discovery, and access available in one application

- Offers the ability to search across disciplines and DAACs

- For the last live demonstration, I'll go through
  - the interface's filtering options to hone a search for SMAP L3 Radiometer Global Daily 36 km EASE-Grid Soil Moisture (SPL3SMP)
  - available ordering and subsetting options
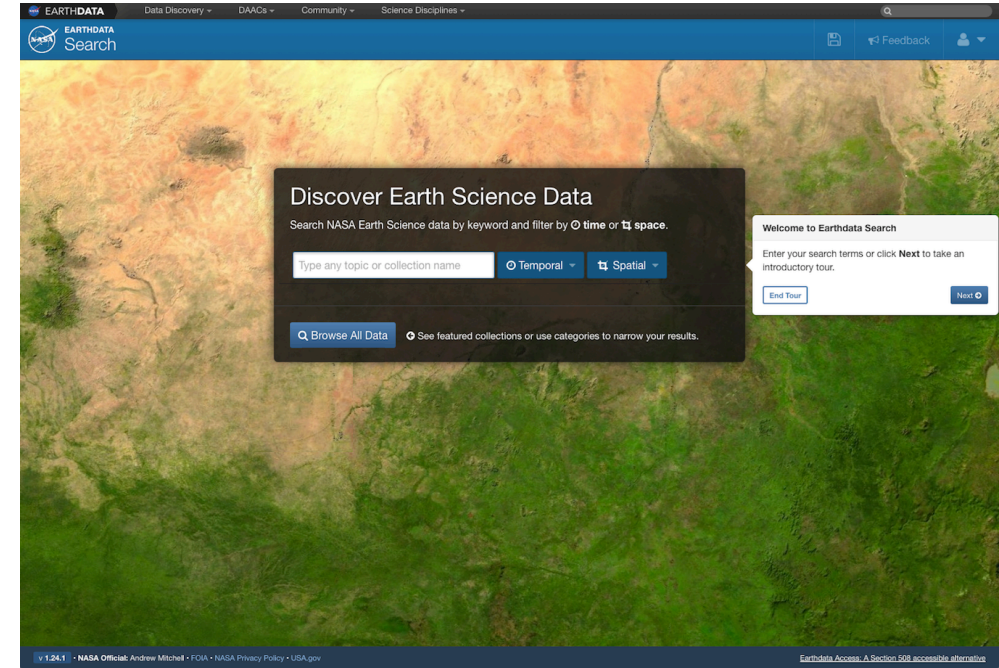
A Quick Comparison of Soil Moisture Across Time…
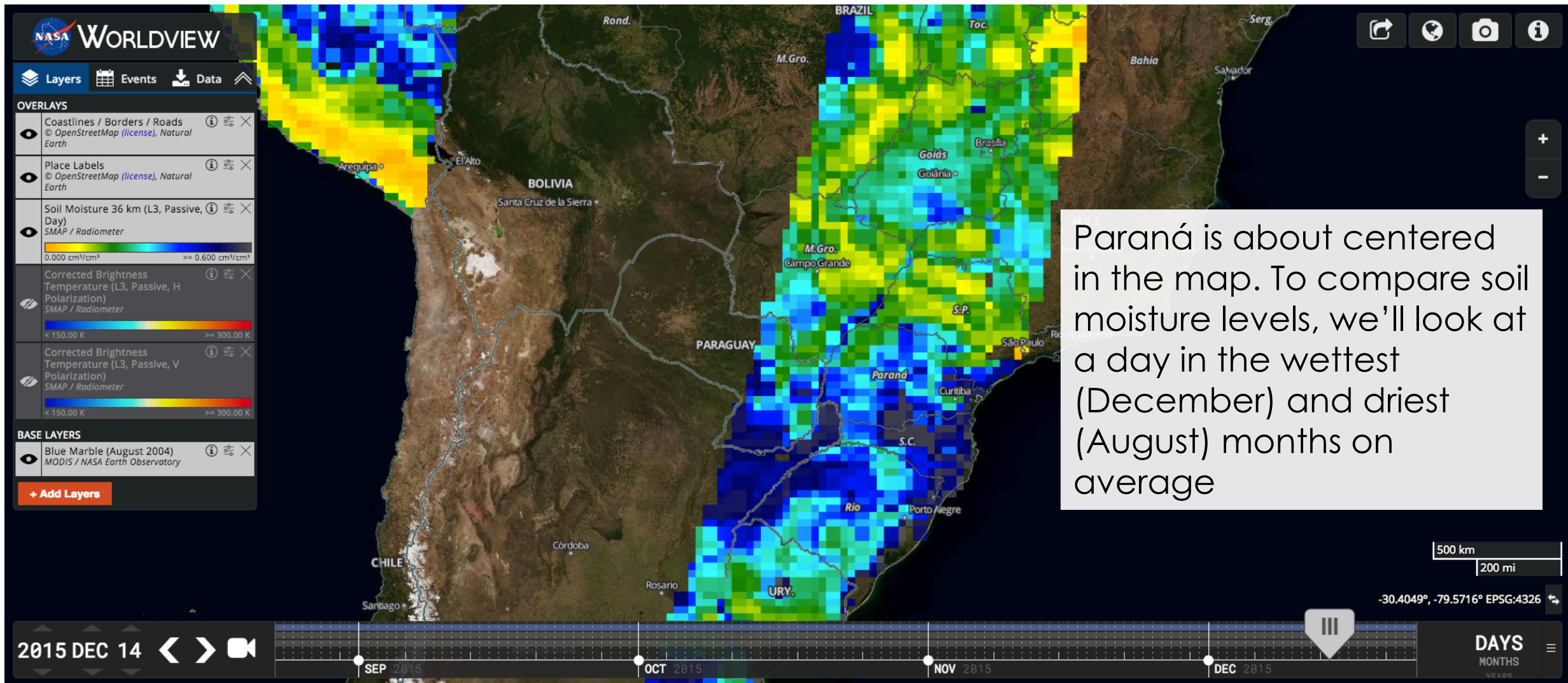
Paraná is about centered in the map. To compare soil moisture levels, we'll look at a day in the wettest (December) and driest (August) months on average

A Quick Comparison of Soil Moisture Across Time...

8 August 2015 has a similar swath as 14 Dec 2015 (previous slide)

A Quick Comparison of Soil Moisture Across Time...

You can use the **Share this Map** option to copy links for the two days that you would like to compare and view them in browser windows placed side by side for a quick visualization of the soil moisture differences between the two dates
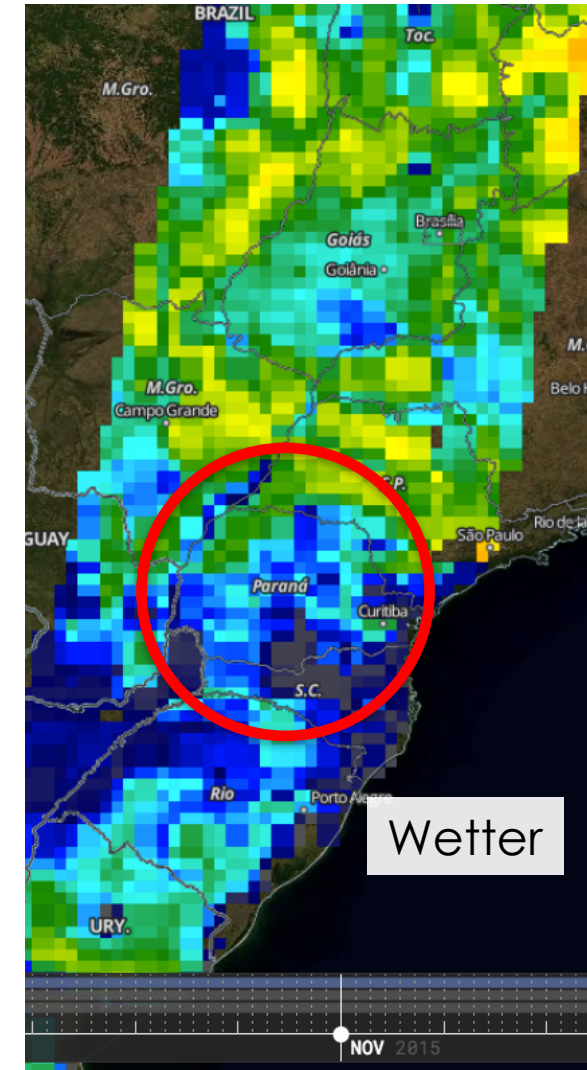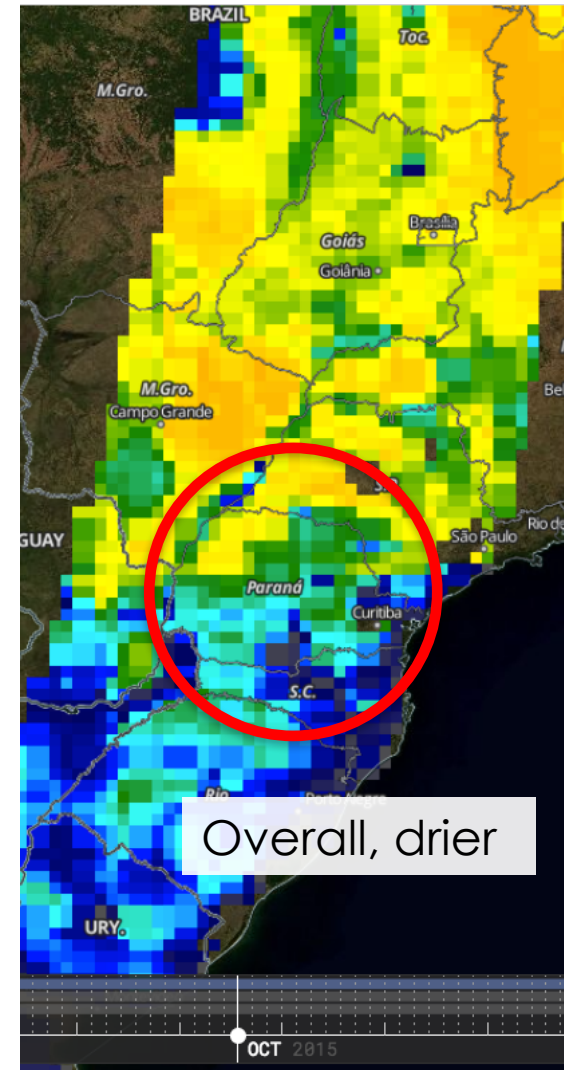
Downloading from Worldview:

Switch to the Data tab

Tick this box to select this day's data

Downloading from Worldview:

Advance to the next day of Soil Moisture data and tick the box – notice that the data panel indicates "2 SELECTED"

Downloading from Worldview:

Clicking on individual file names (in blue) in the top part of the box will download just that file to your machine. Depending on your browser, you may need to hover and right click on the .qa and .xml files and choose the **Save link as** option to save them to your machine rather than have them just open in a separate window or tab.

Clicking on the bottom of the box on either **List of Links** or **List of cURL Commands** will open a new tab or window in your browser with instructions on how to use these options (see next slide)

Click the "Download Selected Data" button and this dialogue pops up. You can remove files from your order and explore your download options.

Downloading from Worldview

Download Links

```
https://n5eil01u.ecs.nsidc.org/DP4/SMAP/SPL3SMP.004/2015.08.08/SMAP_L3_SM_P_20150808_R14010_001.h5
https://n5eil01u.ecs.nsidc.org/DP4/SMAP/SPL3SMP.004/2015.12.14/SMAP_L3_SM_P_20151214_R14010_001.h5
```

Using wget to Bulk Download Your Data

1) Copy the links above and paste into a text document. Save it as "links.txt"
2) Execute the following command to download all of your requested files:

```
wget --input-file=links.txt
```

Using Free Download Manager for Windows to Bulk Download Your Data

1) Copy the Download Links above to your clipboard
2) In Free Download Manager, go to File | Import | Import list of URLs from clipboard

Download Commands

Using cURL to Bulk Download Your Data

Mac OS X / Linux

1) Copy the Download Commands above and paste into a text document. Save it as "download.sh"
2) Execute the following command to download all of your requested files:

```
sh ./download.sh
```

Windows

1) Copy the Download Commands above and paste into a text document. Save it as "download.bat"
2) Execute the following command to download all of your requested files:

```
download.bat
```

Search & Access SMAP Data from Earthdata Search

Click to login to Earthdata

Keyword search and filter options

Click to submit help request or feedback

Collections pane

Faceted filter pane

Add this collection to a project

Search & Access SMAP Data from Earthdata Search

Search & Access SMAP Data from Earthdata Search

Search & Access SMAP Data from Earthdata Search

If you don't already have an Earthdata Login, you will have to register for one before ordering data

Once you've logged in, you'll see that the interface looks slightly different. You can now save projects, view other projects you've saved, and look through your order history

Click to save this setup as a project

Review contact information, recent orders, saved projects, or logout of your account

Clicking the – symbol will remove this collection from your dataset

Set Temporal Search Filter

1. Login

2. Use the "Recurring?" option to limit the granules (files) returned to the dates between Aug 8 and Dec 14, 2015

Set Temporal Search Filter

Notice the temporal search details display

Notice the granule count has dropped from 919 to 129 granules
Set the spatial search filter over Paraná, using the rectangle option

Set Spatial Search Filter

With the spatial search set, the coordinates are displayed along with the details of my temporal search criteria

Add the current project to your collection and view it. This is optional – you don't have to use the project feature to order data

Set Spatial Search Filter

When you click on the text that says **8 Granules** the pane changes to a new view displaying all 8 granules

Remove collection from the current project

View collection details

Granules Listed

Click the download icon to download individual files or the X symbol to delete a file from the list. Because there's a large number of files we aren't interested in, we could click on the two dates we're interested in and do a direct download. For this example, we'll delete all the granules we aren't interested in

Notice that clicking on a granule name displays the extent of the file on the map

Download single granule data

View granule details

Remove granule

Configure and download single granule data

Granules Culled and Ready to Customize and Order

3. Click the download icon to download individual files

Customizing My Download

4. Select **Customize Product**

5. Set the Output file to **GeoTIFF**

6. The **Spatial Subsetting** will populate with the coordinates used in your spatial search criteria

7. Under **Band Subsetting**, click to deselect all options

8. Choose the parameters you want
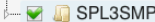
Customizing My Download

Choose the parameters you want
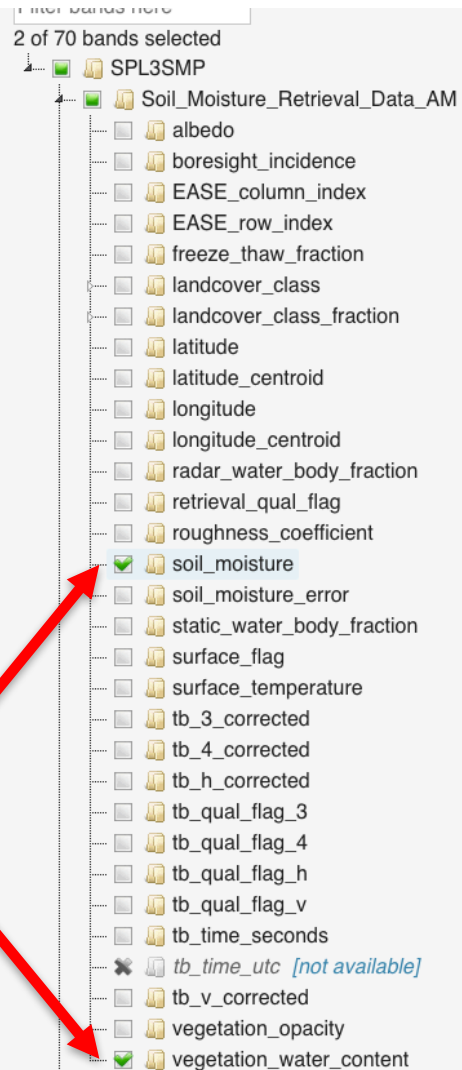
Submitting a SMAP Request

Retrieving a SMAP Output

You can click the html link to view request details or click the zip file to download everything at once

The following collections are being processed

When the data becomes available, an email containing download links will be sent to the address you provided.

- **SMAP L3 Radiometer Global Daily 36 km EASE-Grid Soil Moisture V004** `Complete`

  Your request is complete and can be downloaded using the following urls:
  https://n5eil01u.ecs.nsidc.org/esir/5000000041518.html
  https://n5eil01u.ecs.nsidc.org/esir/5000000041518.zip

Request status – when complete, URLs are displayed

Next Steps

❯ Back to Earthdata Search Results
❯ Start a New Earthdata Search Session
❯ View Your Download Status & History

Retrieving my SMAP Output:

When you choose to reformat output to GeoTIFF, you will receive one tif per band selected for each granule in your request

9. Download the soil moisture tif images

Output files for request id: 5000000040524

Click on the following link for a Request Summary:

requestSummary.txt

Retrieve list of files as a text listing (no html):

5000000040524.txt

Download all files in a single Zip file:

5000000040524.zip

Click on the following links for generated output files:

For Input Granule: 105619863

SMAP_L3_SM_P_20150522_R14010_001_Soil_Moisture_Retrieval_Data_AM_albedo_13b20a7e.tif (<1 MB, SCIENCE, image/tiff)
SMAP_L3_SM_P_20150522_R14010_001_Soil_Moisture_Retrieval_Data_AM_boresight_incidence_13b20a7e.tif (<1 MB, SCIENCE, image/tiff)
SMAP_L3_SM_P_20150522_R14010_001_Soil_Moisture_Retrieval_Data_AM_EASE_column_index_13b20a7e.tif (<1 MB, SCIENCE, image/tiff)
SMAP_L3_SM_P_20150522_R14010_001_Soil_Moisture_Retrieval_Data_AM_EASE_row_index_13b20a7e.tif (<1 MB, SCIENCE, image/tiff)
SMAP_L3_SM_P_20150522_R14010_001_Soil_Moisture_Retrieval_Data_AM_freeze_thaw_fraction_13b20a7e.tif (<1 MB, SCIENCE, image/tiff)
SMAP_L3_SM_P_20150522_R14010_001_Soil_Moisture_Retrieval_Data_AM_landcover_class_Bands_1_13b20a7e.tif (<1 MB, SCIENCE, image/tiff)
SMAP_L3_SM_P_20150522_R14010_001_Soil_Moisture_Retrieval_Data_AM_landcover_class_Bands_2_13b20a7e.tif (<1 MB, SCIENCE, image/tiff)
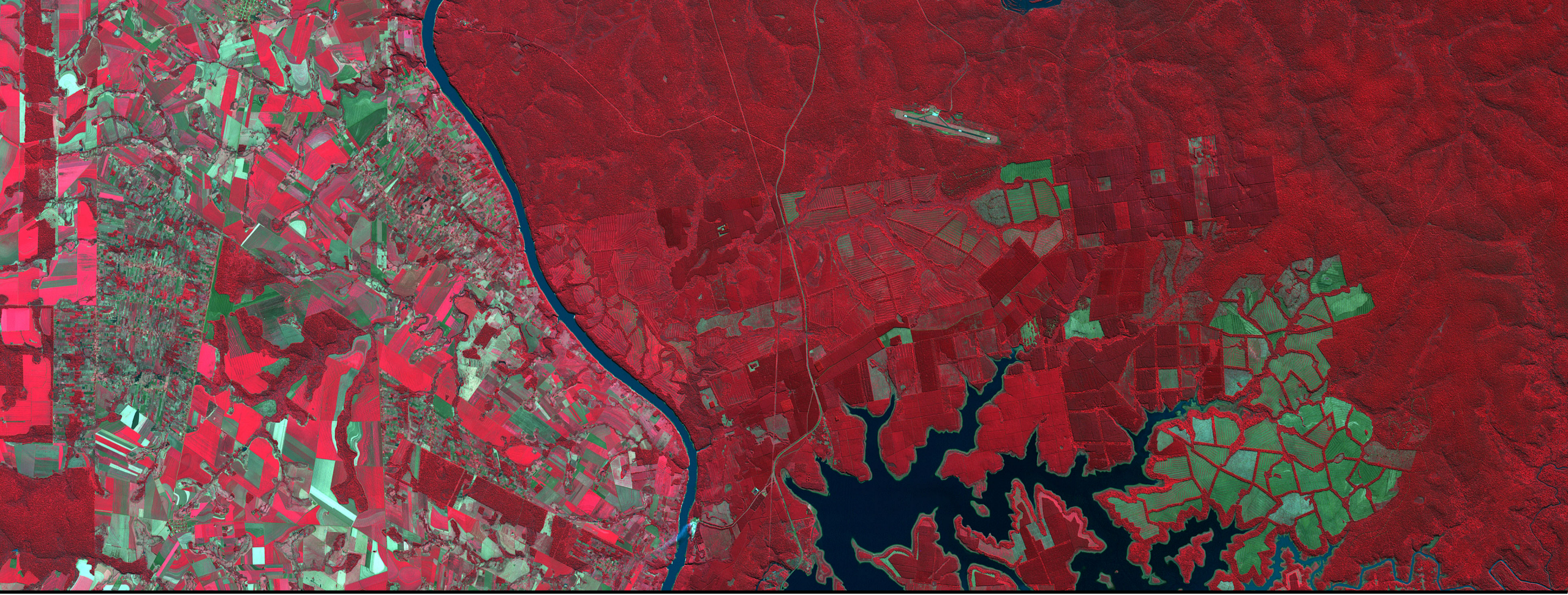SMAP_L3_SM_P_20150522_R14010_001_Soil_Moisture_Retrieval_Data_AM_landcover_class_Bands_3_13b20a7e.tif (<1 MB, SCIENCE, image/tiff)
SMAP_L3_SM_P_20150522_R14010_001_Soil_Moisture_Retrieval_Data_AM_landcover_class_fraction_Bands_1_13b20a7e.tif (<1 MB, SCIENCE, image/tiff)
SMAP_L3_SM_P_20150522_R14010_001_Soil_Moisture_Retrieval_Data_AM_landcover_class_fraction_Bands_2_13b20a7e.tif (<1 MB, SCIENCE, image/tiff)
SMAP_L3_SM_P_20150522_R14010_001_Soil_Moisture_Retrieval_Data_AM_landcover_class_fraction_Bands_3_13b20a7e.tif (<1 MB, SCIENCE, image/tiff)
SMAP_L3_SM_P_20150522_R14010_001_Soil_Moisture_Retrieval_Data_AM_latitude_13b20a7e.tif (<1 MB, SCIENCE, image/tiff)
SMAP_L3_SM_P_20150522_R14010_001_Soil_Moisture_Retrieval_Data_AM_latitude_centroid_13b20a7e.tif (<1 MB, SCIENCE, image/tiff)
SMAP_L3_SM_P_20150522_R14010_001_Soil_Moisture_Retrieval_Data_AM_longitude_13b20a7e.tif (<1 MB, SCIENCE, image/tiff)
SMAP_L3_SM_P_20150522_R14010_001_Soil_Moisture_Retrieval_Data_AM_longitude_centroid_13b20a7e.tif (<1 MB, SCIENCE, image/tiff)
SMAP_L3_SM_P_20150522_R14010_001_Soil_Moisture_Retrieval_Data_AM_radar_water_body_fraction_13b20a7e.tif (<1 MB, SCIENCE, image/tiff)
SMAP_L3_SM_P_20150522_R14010_001_Soil_Moisture_Retrieval_Data_AM_retrieval_qual_flag_13b20a7e.tif (<1 MB, SCIENCE, image/tiff)
SMAP_L3_SM_P_20150522_R14010_001_Soil_Moisture_Retrieval_Data_AM_roughness_coefficient_13b20a7e.tif (<1 MB, SCIENCE, image/tiff)
SMAP_L3_SM_P_20150522_R14010_001_Soil_Moisture_Retrieval_Data_AM_soil_moisture_13b20a7e.tif (<1 MB, SCIENCE, image/tiff)
SMAP_L3_SM_P_20150522_R14010_001_Soil_Moisture_Retrieval_Data_AM_soil_moisture_error_13b20a7e.tif (<1 MB, SCIENCE, image/tiff)
SMAP_L3_SM_P_20150522_R14010_001_Soil_Moisture_Retrieval_Data_AM_static_water_body_fraction_13b20a7e.tif (<1 MB, SCIENCE, image/tiff)
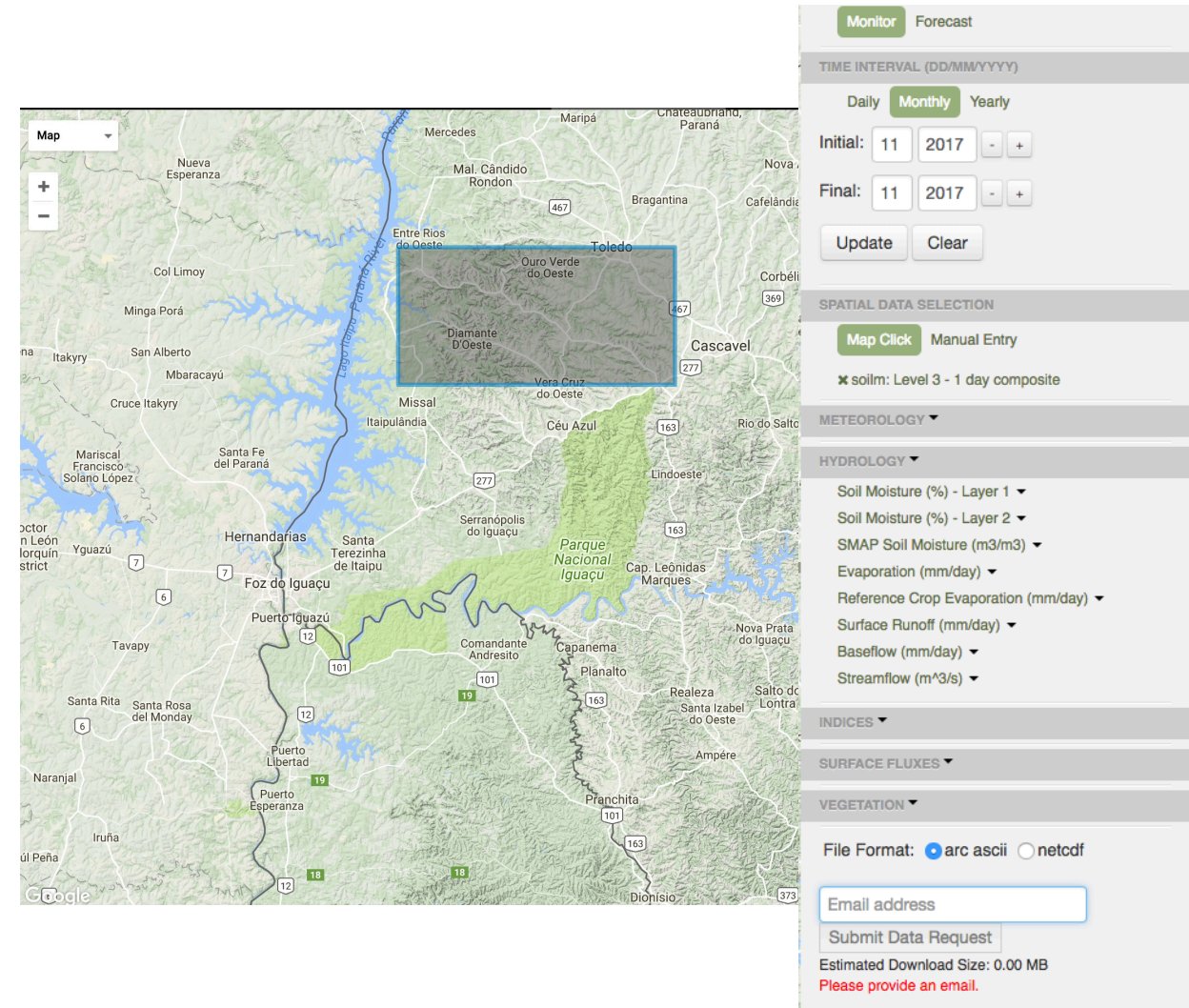
SMAP Data Analysis

Extracting SMAP Soil Moisture

1. Go to the U.S. Flood and Drought Monitor tool from Princeton University:
   - http://stream.princeton.edu/LAFDM/WEBPAGE/interface.php?locale=en
   - This is the most direct way to extract SMAP soil moisture values

Specifying Parameters

2. In the upper-right window, select **Spatial Data**

3. Under **Time Interval**, select **monthly**. Specify **Jan. 2016**

4. Draw a box over the watershed

5. Under **Hydrology**, select **SMAP soil moisture** > **Level 3-1day composite**

6. For **File Format**, select **arc ascii**

7. Specify your email and click **Submit Data Request**

Opening the File

8. Open the text file with Excel
    – The results contain the average soil moisture for the month of Jan. 2016 for the pixels within the rectangle specified

9. Repeat the same extraction for Jan 2017, Feb 2016, and Feb 2017